AN ECONOMETRIC INVESTIGATION OF THE RELATIONSHIP BETWEEN IRISH HOUSE PRICES AND THEIR ESTIMATED FUNDAMENTAL VALUE

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The issue of Irish house price inflation has been a contentious one in recent years. Many have speculated that dramatic price increases are the result of a bubble that has meant houses are now valued in excess of their fundamental value. In an effort to explore this issue, Deirdre Reilly examines the roles of income, interest rates, population and expected capital gain.

Introduction

Between 1995 and 2005, second-hand house prices in Ireland increased by 345%.[1] This is far in excess of the 38% increase in the consumer price index.[2] The economic significance of such large price movements cannot be understated considering the huge proportion of household wealth that is held in this asset. Kenny (1998) notes that consumer behaviour can be significantly affected by such disproportionate changes in house prices relative to other goods and services. However, to conclude on the basis of observation, as many people have done in recent years, that houses prices are far in excess of their fundamental value, would be to overlook the strong economic performance of the economy and the significant demographic shifts in the population. In this paper I propose to investigate whether a speculative bubble exists. I will first review the literature on the subject and then set out my methodology. Following that, I will discuss the econometric process. Finally, I will present my findings and suggest some direction for further research.

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[1] Department of the Environment
[2] EcoWin Pro

Literature Review

There have been a number of studies investigating the relationship between Irish residential house prices and their estimated fundamental value. Stevenson (2005) analyses this relationship under a number of methodological approaches, in general finding the existence of a speculative premium. Kenny (1998) examines the causes of the house price movements in Ireland between 1975 and 1997. After modelling housing demand and supply, he found that severe supply-side constraints explain the large increase in house prices.

Methodology

There are alternative approaches to modelling the fundamental price of houses (P), such as inverted demand models, error correction models (ECMs), and asset based pricing models. Inverted demand models are quite simple but their results raise serious diagnostic concerns, are highly unstable and their variables are often non-stationary. ECMs are much more desirable as they allow for short-run dynamics and deviations from long-run equilibrium. I would like to use such a framework, however ECMs use many variables; given the lack of data on the Irish housing market it is likely that that I would run into over-parameterisation difficulties. Instead I will use a variation of the asset based pricing model developed by Levin and Wright (1997). This model is based on the assumption that due to the supply constraints that housing operates under, changes in prices are mainly determined by demand shocks and that changes in demand conditions will determine expectations regarding future price appreciation. The motivation for choosing Levin and Wright's model is the lack of reliable rental data, which underpins many of the other asset-based models, such as that used by Olaf Weeken (2004) in measuring fundamental house prices for the Bank of England. Levin and Wright believe that the fundamental price of a house can be defined by the sum of the price (based on owner-occupation and zero capital gain) and the present value of the expected capital gain. The expected capital gain at time t is assumed to be determined by the capital gain in the previous period (g_{t-1}), where

$$g_{t-1} = (P_{t-1} - P_{t-2}) / P_{t-2}$$

I defined the present value of the expected capital gain as $\boldsymbol{E_t}$, and it is calculated as $\boldsymbol{[g_{t-1}/(1 + I_t)]}$. The authors assume that fundamental value based on zero capital gain is related to the income (Y) and the one-period interest rate (I). However, I believe that the population aged 25-44 (POP) is also a significant factor in determining the fundamental value. This age category should best capture the demographic influences on house prices as it is the main house buying age group (Duffy and Quail, 2005), detects the key demographic trends, and since this is the age category of most migrants, it should also pick up the migration effects (Stevenson, 2005). Therefore, the specification of the model I will use for determining fundamental value of house prices is as follows:

$$\boldsymbol{P_t = \alpha + \beta_1 Y_t + \beta_2 I_t + \beta_3 POP_t + \beta_4 E_t + \varepsilon}$$

Annual data from 1975 to 2005 was used to estimate the model. 1975 was chosen as the start year as it is the first year that the mortgage rate is available.

Regression

To begin, following the Dolado procedure, each variable was tested for a unit root. When a Dickey-Fuller (DF) and Augmented Dickey-Fuller (ADF) test was conducted on P. Looking at the model with a constant and a trend, the DF version was preferred under the Schwarz Bayesian Criterion (SBC), Akaike Information Criterion (AIC) and Hannan-Quinn Criterion (HQC). The Log-Likelihood (LL) criterion would have selected ADF with 5 lags (=5). Since the sample size is small relative to the number of variables the DF version was chosen so as to reduce the risk of over-parameterisation. However, the choice of the order is subject to an important degree of uncertainty. Choosing ρ too small results in a test that will over-reject the null, but choosing ρ too big reduces the power of the test.

The DF had a test statistic of 2.198, and considering the critical value was –3.60, the null hypothesis that P had a unit root could not be rejected. In this case the version chosen would not have made a difference to the outcome, as none tests of could have rejected the null.

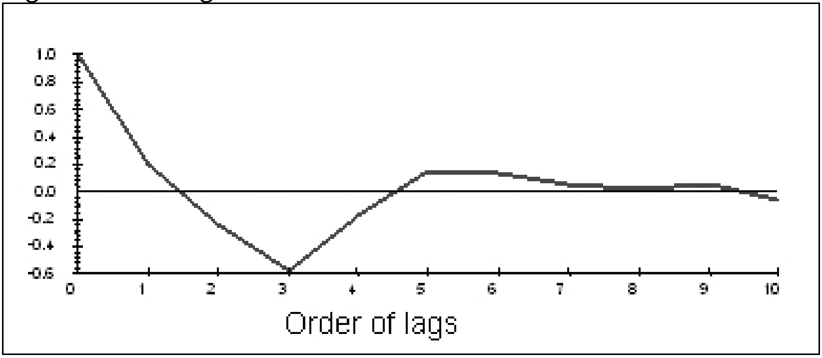
Following the Dolado procedure, I estimated the regression under the null, i.e. omitting Y_{t-1}, and tested the significance of the time trend (T). The probability that the coefficient on the time trend equalled zero was 0%, making the variable very statistically significant. Therefore, the test statistic is distributed asymptotically standard normal, yet it is still not possible to reject the null of unit root because the test statistic is greater than the 5% standard normal critical value of –1.96. This implies that P does have a unit root. Similarly for Y and E, the null hypothesis of a unit root could not be rejected, even using the standard normal critical values, after showing that a time trend was significant. For both POP and I, all the information criteria preferred ADF(5). With test statistics of –3.649 and –3.633 respectfully and both with a critical value of –3.603, the null hypothesis of a unit root could be rejected in both cases.

As P, Y and E appeared to be integrated of order one, the next step was to check if any of the variables were co-integrating. Theoretically it seemed unlikely that there would be a stable long run relationship between P and Y or Y and E but perhaps one may exist between P and E. To test for co-integration between P and Y, P was regressed on a constant and Y, and checked the residuals for a unit root. With a 95% critical value of –3.591, neither the DF nor any of the ADF test statistics were significant. Therefore the null hypothesis that residuals have a unit root could not be rejected, signalling that P and Y are not co-integrating. Analysing the pairs (P, Y), (P, E), and (Y, E), and the set of variables (P, Y and E) in the same manner revealed that they were not co-integrating either.

However, the original regression model is not balanced; the variables P, Y and E are integrated of order one while variables I and POP are integrated of order zero. The unit root variables cause major problems as the series are not stationary and standard asymptotic distributions are no longer appropriate. First-differencing the variables with unit roots, produces the differenced variables DP, DY and DE. A time trend was inserted as this was suggested to be appropriate by the DF and ADF tests.

Next, DP was regressed on C, T, I, POP, DY and DE. A unit root test of the residuals was conducted to check if these variables were stationary. There was disagreement among the information criterion as to the stationarity of the model. The LL, AIC and HQC preferred the ADF(5), which had a test statistic of –3.377. When compared to the critical value of –5.542, the null hypothesis of unit roots in the residuals could not be rejected. If there is a unit root in the residuals, then the regression is spurious rendering the reported t- and F- statistics invalid. However, the SBC preferred the more parsimonious ADF(2), which had a test statistic of –6.173, allowing the null to be rejected, thus implying stationarity. Considering there was very little difference in the preferences of the models ADF(2) and ADF(5), and bearing in mind the reduction in the number of observations available to test the ADF(5), which would diminish the power of the test, to reject the null hypothesis, it was decided to cautiously reject the null hypothesis of unit root. Also, as the autocorrelogram of residuals (below) falls off quickly, this indicates that the model is stationary.

Figure 1. Correlogram



The DW statistic for the model of 1.581 lay in between the upper (1.850) and lower (1.028) bound for the 5% critical value, indicating that the test for serial autocorrelation was inconclusive. Considering the diagnostic test for serial correlation of the errors, indicates that the null cannot be rejected. To investigate further a test for serial correlation of the errors was carried out. This showed that correlation of order 1 and 2 was insignificant but that the correlation of order 3 was very significant. A correction was made for the potential problem by estimating the equation using the Cochrane-Orcuttt (C-O) iterative procedure. The second order scheme was chosen as it produced the best diagnostic results. The C-O summary regression results and the OLS diagnostic results are presented below.

Table 1. Regression Results

Regressor	Coefficient	Standard Error	t-Ratio	Probability
C	-39553.1	42168.5	-0.938	0.358
T	-1030.7	781.847	-1.318	0.201
I	-500.26	1222.4	-0.409	0.686
POP	28.98	22.957	1.262	0.22
DY	4.229	0.783	5.404	0
DE	1065688	1814768	0.587	0.563

Table 2. Relevant Statistics

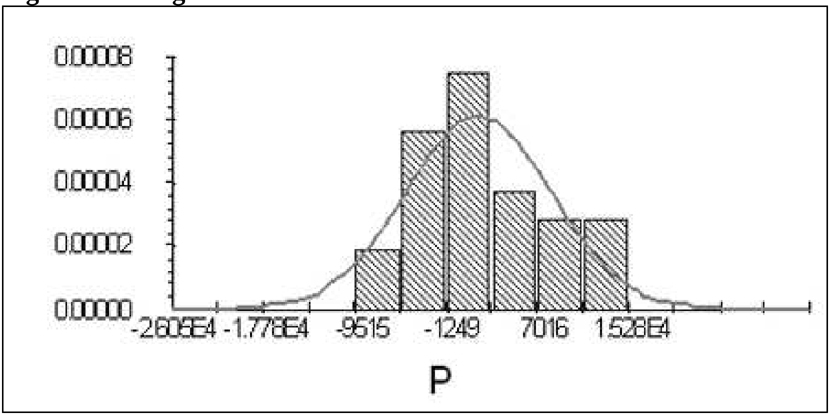
Statistic	Value
R-squared	0.906
R-bar-squared	0.869
F-Stat F(7,18)	24.715 [0.000]
DW-Statistic	2.388

Table 3. Diagnostic Results

Test Statistic	LM Version	Probability	F Version	Probability
Serial Correlation	1.700	0.192	1.357	0.257
Functional Form	0.071	0.791	0.053	0.820
Normality	0.750	0.687	-	-
Heteroscedasticity	9.205	0.002	12.734	0.001

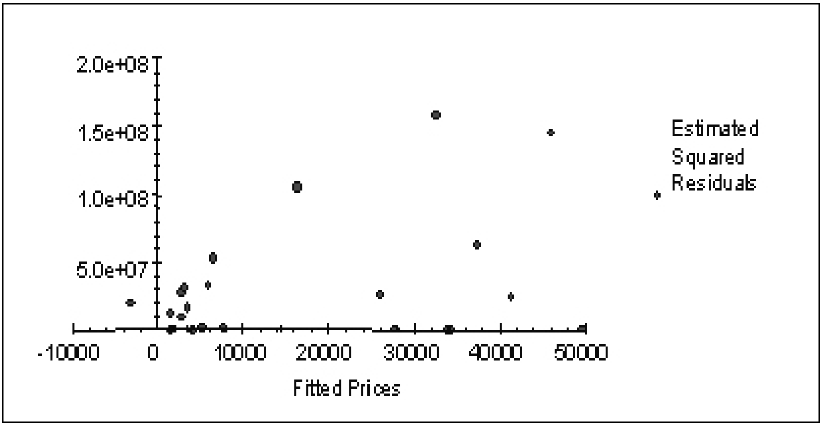
The C-O regression had a DW statistic of 2.388, indicating autocorrelation is no longer a problem. The insignificant statistic for the Ramsey RESET test, suggests that the functional form is correct. The Chi-squared test for normality of the OLS residuals is insignificant, supporting the null hypothesis of zero skewness and normal kurtosis. Considering the histogram of C-O residuals also suggests normality of the residuals.

Figure 2. Histogram of Residuals



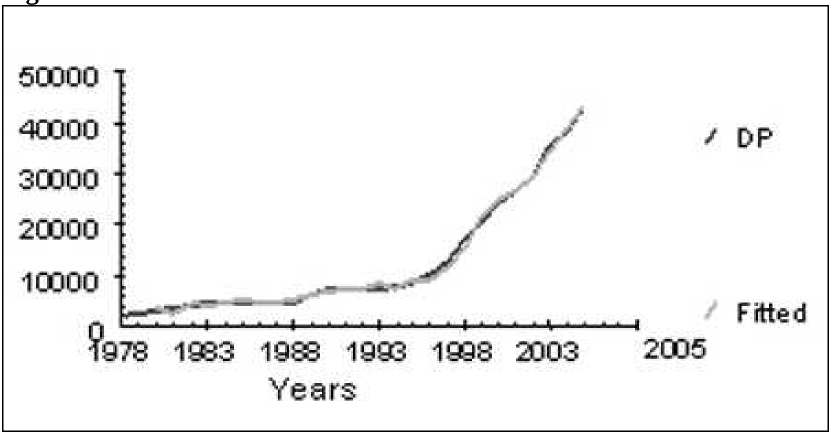
The test for hetroscedasticity indicates that the model displays significant homoscedasticity. Considering the scattergram of C-O estimated residuals and the fitted P values, there appears to be little systematic pattern. This implies that the transformed data is relatively hetroscedastically distributed.

Figure 3: Scattergram of Estimated Squared Residuals Against Fitted Prices



The coefficient of determination (R^2) is a measure that indicates how well the sample regression line fits the data. The R^2 for this model is 0.906, indicating that over 90% of the variation in P is explained by the variation in the regressors. The plot (below) of the actual and estimated values of P indicates that a close relationship exists between them.

Figure 4: Plot of Fitted and Actual Values



The R-bar-squared statistic takes into account that adding another variable to the model has the negative effect of reducing the model's degrees of freedom. At 87%, it is also an encouraging statistic. However, it must be stressed that the aim of the paper is not to maximise the fit of the model but rather to estimate fundamental house prices.

The F-statistic calculates the overall significance of the fitted regression line, that is, it tests the null hypothesis that the coefficients of all the variables are zero. This model has a highly significant F-statistic and a correspondingly negligible p-value, thus allowing the null hypothesis to be rejected.

For this model the only statistically significant variable is DY. The null hypothesis that the coefficient of DY is zero can in fact be rejected at the 0.001% significance level. The coefficient has the correct theoretical sign, that is, an increase in the expected capital gain would lead to an increase in the price. The variables C, T, I, POP and DE are statistically insignificant. The coefficients on I, POP and DE have the theoretically correct sign; indicating that an increase in interest rates leads to a fall in prices, an increase in the population leads to an increase in prices and an increase in the expected capital gain leads to an increase in prices.

Given the high F-statistic and theoretically correct signs of the variables, yet their small t-statistics suggests a problem of multicollinearity. Correlation among the variables could make them independently insignificant. To investigate this further, the pair-wise correlation between the explanatory variables was estimated. The pairs (DY, POP), (I, DY) and (POP, I) were highly correlated, having a correlation co-efficient of 0.87, -0.84 and -0.91 respectfully. The remaining pairs (I, DE), (DE, P) and (DY, DE) were not as highly correlated; having a correlation co-efficient of –0.25, 0.25 and 0.36 respectfully.

Considering as the pair (POP, I) was highly correlated and both variables were individually insignificant, I did a variable deletion test on the pair. Jointly they were still insignificant; the null hypothesis that their coefficients are both zero could not be rejected by the Lagrange Multiplier (LM), Likelihood Ratio (LR) or F-test. Extending the test to include the deletion of the variable POP also resulted in an insignificant outcome under each test. Despite the low degree of multicollinearity between the pairs (POP, DE) and (DE, I) a variable deletion test was carried out for each, both of which were insignificant. Therefore, although multicollinearity is a problem in the model, some of the variables probably play a very limited or insignificant role in explaining house prices.

Speculative Bubble?

The fitted values from the above regression are the implied fundamental values. As can be seen from the plot of actual and fitted house prices, they follow each other very closely throughout the period examined. According to this model, the largest premium to fundamental value was in 1981, when actual prices were 45.6% above their fitted value. It is difficult to find any explanation for this exceptionally large premium. Between 1980 and 1987 actual house prices fluctuated above and below their fundamental value. From 1987 through to the early 1990s the market was generally at a discount to its fundamental value. From 1996 to 1998, house prices were overvalued by an average of 8.3%. This was the longest sustained premium observed over the period studied. Since 1999 house prices have been at a small discount to their fundamental value, apart from 2003 and 2005, which had a premium of 2.5% and 0.2% respectfully.

From this analysis it appears that there was a speculative component present in the market in 1981 and between 1996 and 1998. Excluding this, there has for no sustained time horizon been a premium or discount to fair value maintained, indicating that house prices have otherwise been at their fundamental value. Stevenson (2005) believes that the premium in the late 1990s may be due to the market being driven by expectations. The strong consumer confidence and general confidence in the economy could account for the premium to fundamental value. Considering the very robust growth of the Irish economy since the mid-nineties and the strong population growth over the period, it may be the case that the dramatic increase in house prices can be justified in an economic fundamental sense.

However, this does not preclude the affordability difficulties experienced by many people attempting the access the market. Poterba (1991) argued that prices in the housing market are largely determined by uninformed investors and therefore their expectations cannot be expressed as rational. They are inclined to over rely on past price movements to the extent that, particularly during periods of bubble-like price growth, such movements play the role of an expectations operator, as opposed to a measure of fundamental value. This argument brings into question the very model used to estimate fundamental value. Furthermore, the results of this econometric analysis must be interpreted with extreme caution as there is the possibility of a unit root in the data generating process, which if present would make the regression spurious and the findings invalid.

Further Research

It would be very interesting to do another study addressing the same issue but using an error-correction framework. To overcome the over-parameterisation difficulties discussed previously it may be possible to use quarterly data as opposed to annual data. Additionally, it would be enlightening to do a separate analysis of house prices within different areas of Ireland. Many experts argue that a speculative bubble exists in a number of sub-markets, notably those of Dublin, Cork and Galway, but that for the country as a whole, houses are fairly priced. It would be also be very desirable to investigate and perhaps account for the autocorrelation that appears in the third lag of this model.

Data

The following data was used in the analysis:

P House prices, as measured by the second-hand house prices, published by the Department of the Environment. Viewed at, http://www.environ.ie/ accessed on 15/02/2007.

Y Disposable income, as measured by the Gross National Disposable Income at current market prices, published by the CSO between 1975 and 1994 and published by EcoWin Pro between 1996 and 2005, the figure for 1995 is an average of the figure from both sources. Viewed at http://www.cso.ie accessed on 15/02/2007] and EcoWin Pro, ‘Ireland, Income Approach, Disposable Income, National, Gross, Total, Current Prices’.

I Interest rates, as measured by the building society mortgage interest rate, published by the CSO. Viewed at, http://www.cso.ie accessed on 15/02/2007.

POP Population aged 25-44, published by the CSO. Viewed at, http://www.cso.ie accessed on 15/02/2007.

Bibliography

EcoWin Pro. '*Ireland, Harmonized Consumer Prices, (HICP), total, Index, EUR*'.

Department of Environment (2007) 'Housing Statistics'. *Department of the Environment, Heritage and Local Government.* Viewed at http://www.environ.ie/DOEI/doeipub.nsf/0/daac160e1d73c27d80256f0f003dbc05/$FILE/Housing%20Statistics%20%20for%20Dept%20web%20site_%202006%20commencements%202006%20%20to%20Orla%2012%20March'07.XLS accessed on 21/03/2007.

Duffy, D. and Quail, A. (2005) *First-Time Buyers in the Irish Housing Markey: A Survey of Permanent TSB First-Time Buyers*. Dublin: ERSI and Permanent TSB.

Kenny, G. (1998) *The Housing Market and the Macroeconomy: Evidence From Ireland*. Dublin: The Central Bank of Ireland. Viewed at http://www.centralbank.ie/data/TechPaperFiles/1RT98.pdf accessed on 21/02/2007, p. 4.

Levin, E.J. and Wright, R.E. (1997) 'Speculation and the Housing Market'. *Urban Studies*, 34:9:1419-1437. London: Routledge.

Poterba, J. (1991) 'House Price Dynamics: The Role of Tax Policy and Demography'. *Brooking Papers on Economic Activity*, 2:143-203.

Stevenson, S. (2005) *Modelling Housing Market Fundamentals: Empirical Evidence of Extreme Market Conditions*, Cass Business School, City University pp. 3-5. Viewed at http://www.cass.city.ac.uk/faculty/s.stevenson/files/Stevenson%2C_Housing_Markets_%26_Extreme_Conditions.pdf accessed on 21/02/2007.

Weeken, Olaf (2004) 'Asset Prices and the Housing Market'. *Bank of England Quarterly Bulletin*, Spring 2004 pp. 33-42. Viewed at http://www.bankofengland.co.uk/publications/quaterlybulletin/qb04102.pdf accessed on 21/02/2007.